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REGULATORY RATIONING OF ELECTRICITY UNDER A SUPPLY CURTAILMENT,(U)
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10 Jan Paul Acton and Ragnhild Mowill

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REGULATORY RATIONING OF ELECTRICITY UNDER A SUPPLY CURTAILMENT

by Jan Paul Acton
Ragnhild Mowill

1. INTRODUCTION

When the Organization of Arab Oil Producing Countries voted in October 1973 to embargo shipments of oil and oil products and to raise prices in general, all uses of energy came under scrutiny. Electric utilities that rely heavily on fuel oil or natural gas for generation were especially vulnerable to serious disruptions in supplies. A variety of policy measures for affecting demand were considered at that time. These can be divided broadly into (1) measures that would cut consumption by raising prices and (2) measures that would cut consumption by voluntary or mandatory rationing. The merits of these alternative approaches have been debated at length by economists and policymakers. Los Angeles chose to meet its problem with a city ordinance requiring customers to reduce their consumption of electricity relative to the preceding year. CONT'D ON NEXT PAGE

More than two years after the embargo and the curtailment ordinance, the Federal Energy Administration is considering employing "The Los Angeles Plan" nationally, to deal with the impact of natural gas shortages in the electric utilities,[1] and the Federal Power Commission is considering a similar approach in implementing the provisions of the Energy Policy and Conservation Act.[2] Despite the continuing interest in energy policy alternatives, however, few attempts have been made to study the quantitative dimensions of the impact of the energy shortage in 1973-1974; even fewer systematic studies have considered the effectiveness of policy measures that were adopted during this period. Since non-standard regulatory responses--such as this curtailment ordinance--are being increasingly considered by legislatures and regulatory bodies, an analysis of this experience should be useful in the evaluation of alternative policies. It should also be useful to federal policymakers in judging types of approaches that can be taken at the local level, in tailoring federal actions to complement them, and in encouraging those aspects that best meet national and regional objectives.

cont. Our discussion focuses on three questions: What was The Los Angeles Plan? What were its immediate and longer run effects on electricity consumption? What does this experiment suggest about the relative desirability of such an approach were another fuel or other crisis to occur?

2. THE LOS ANGELES APPROACH

The City of Los Angeles is served by the Department of Water and Power (DWP), whose rates require City Council approval. When the oil embargo was imposed, DWP found itself very short of oil for generating electricity. On an annual basis, over half of the department's electricity is generated from oil, and during the winter, an even greater use is made of oil. Because low sulfur oil--necessary for reasons of air pollution abatement--was in short supply, the initial prospects were not good for meeting normal demand for electricity.

Mayor Tom Bradley and the City Council responded quickly with an ordinance to curtail use of electricity. The mayor appointed an ad hoc advisory panel made up of leaders from government, labor, industry, and business to consider means of meeting the shortage. After reviewing such alternatives as burning higher sulfur fuel, a curtailment of business activity to 50 hours per week, and rolling blackouts around the city, Mayor Bradley and the panel proposed, and the City Council enacted, "The Emergency Energy Curtailment Plan of the City of Los Angeles" on December 13, 1973.[3]

THE CURTAILMENT ORDINANCE

Under Phase I of the plan, residential and industrial customers were required to cut use 10 percent and commercial customers 20 percent over the corresponding billing period a year before.[4] Under Phase II (which was never invoked), residential use was to be restricted 12 percent, industrial use 16 percent, and commercial use 33 percent over the corresponding billing period a year before. The penalty for excess use was a surcharge of 50 percent on the <u>entire</u> bill for the first period violation, and cutoff of service for subsequent violations. Overall, the program was successful in reducing demand and avoiding major system outages.

The penalty provisions of the ordinance clearly went beyond a traditional adjustment in the rate structure since the ordinance implied the introduction of a radical discontinuity in the price schedule. This is illustrated for a particular customer in a given month in Fig. 1. Before the ordinance, this customer consumed at Q, his base consumption for this month. The ordinance required him to cut his consumption by r% to (1-r)Q. Beyond this point, the 50% surcharge would go into effect. This implied that for any level of consumption at or below (1-r)Q the normal schedule applied. However, the new marginal price for the first kwh beyond this level was now 50% of the total bill for (1-r)Q kwh plus 1.5 times the marginal price for all additional consumption (for simplicity's sake, we demonstrate using a one-step declining block rate schedule). In general, a customer will exceed the level (1-r) only if his demand curve is so inelastic that it lies totally to the right of the vertical line at the amount (1-r)Q.[5]

We take three approaches in analyzing the impact of the ordinance and accompanying factors on total energy consumption and use by major classes of customer: (1) We make a year-by-year comparison of monthly electricity production (net energy for load) and sales for DWP. (2) Using a statistical model, we adjust for the effects of weather, price, economic activity, and minutes of daylight, and compare "expected" electricity consumption with observed consumption during the curtailment. (3) We compare year-by-year changes for DWP and the three principal private utilities in California. Since a number of national and statewide energy problems and public appeals were common to all utilities, the juxtaposition of the four patterns of consumption will give an indication of the added impact of

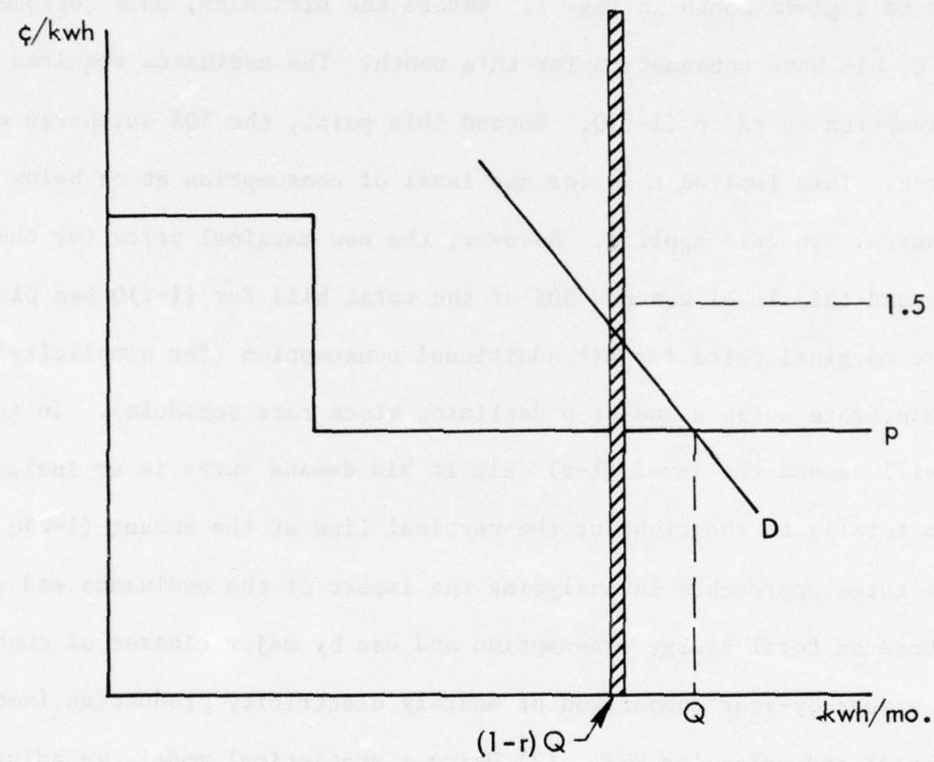

Fig. 1 — Illustration of the price schedule effect of the curtailment provision

an ordinance and associated factors. No single approach reveals the complete impact, but each lends insight to the same underlying process.

3. NOMINAL REDUCTION

Like most utilities in the United States, DWP had a steady growth in electrical sales, which averaged about 7.7 percent from 1950 to 1969 and about 5 percent in the early 1970s. The nominal reduction in energy production and sales is found by comparison with the corresponding month in the baseline period (September 1972 to August 1973). This is the way the ordinance was written, requiring a percentage reduction over the appropriate baseline month. The ordinance was passed on December 13, 1973, and took effect 8 days later. The response to its enactment was rapid and substantial. In the first 11 days the ordinance was in effect, electricity generation fell 14.9 percent when compared with the same 11-day period of 1972. The initial response of all classes of customers was to meet or exceed the required reduction. The reduction was so significant that Phase II, with more stringent requirements, was never invoked. Enforcement of the penalties was postponed (although customers did not know this at the outset), and the ordinance was suspended on May 22, 1974.

Percentage changes over the base period in total electricity sales and sales to class of customers are shown in Figure 2.[6] Sales are shown by month of billing, and generally lag consumption by a little more than one month. Total sales were off by about 20 percent the first two months the ordinance was in effect. In May of 1975, over a year after the ordinance was suspended, total sales were below 1973 levels by about 8 percent. Residential and commercial sales fell rapidly with the enactment of the ordinance and both were about 8 percentage points below that required by the ordinance (18 and 28 percent respectively instead of the required 10 and 20 percent). In the 12 months following the suspension of the ordinance, residential sales remained below 1973 levels by 5 to 10 percent,

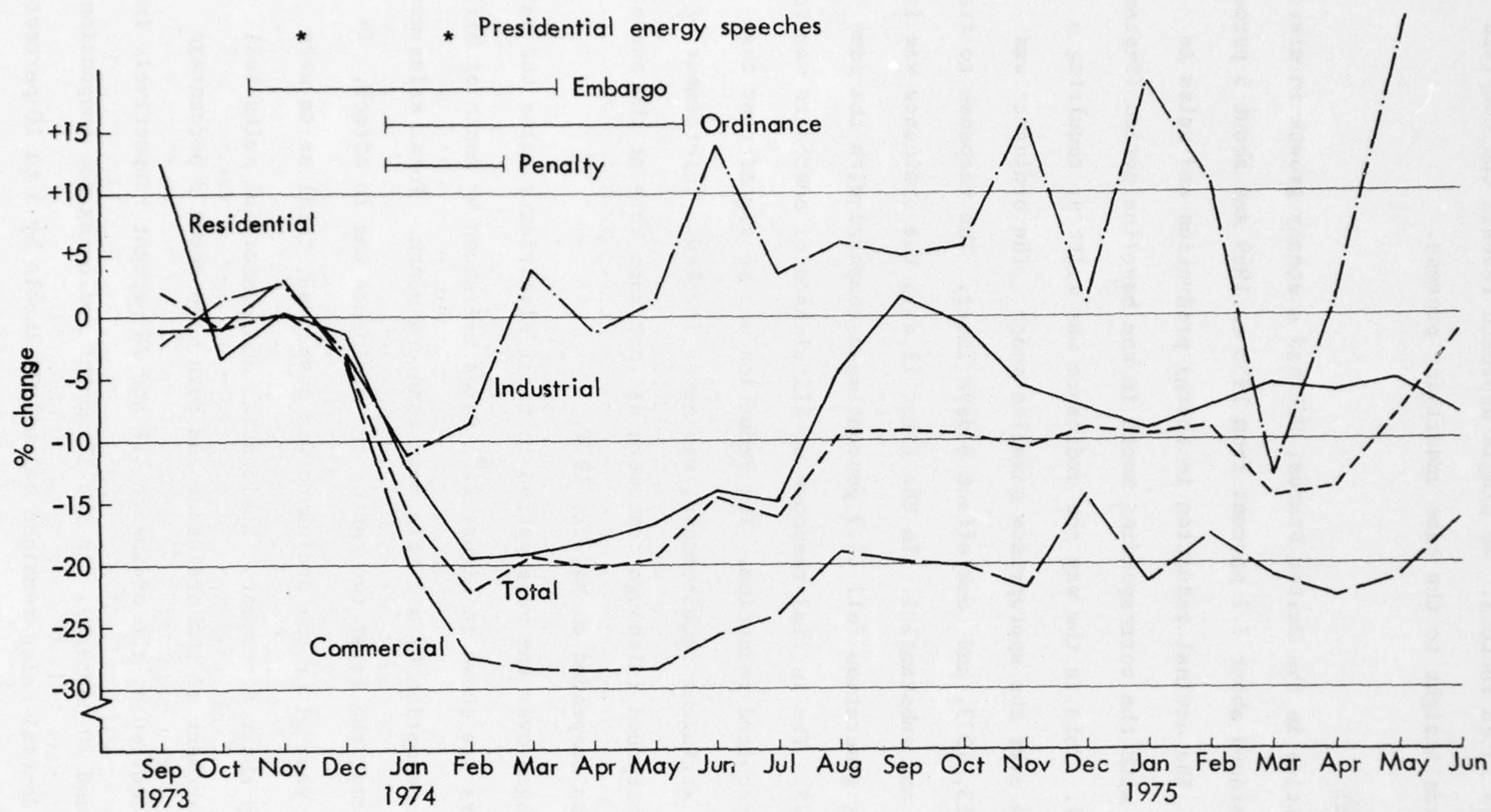

Fig. 2 — Percentage change in monthly electricity sales by customer class, 1973-75 versus 1972-73, Los Angeles Department of Water and Power

and commercial sales were 20 percent below 1973 levels. Although industrial sales initially fell in response to the ordinance, the subsequent pattern is mixed and 1975 levels lie above historic.[7]

The specific conservation measures adopted by individual customers are reviewed in a background report.[8] Changes in lighting--both in the number of bulbs used in a fixture and in hours of lighting--accounted for most of the reduction at the individual level. Most commercial establishments met their 20 percent target with changes in lighting alone. To a lesser degree, adjustments in air conditioning--changing the temperature settings as well as letting the equipment run intermittently rather than continuously--were important. Larger customers found it advantageous to go beyond lighting and adjust scheduling and equipment use; in some cases, they undertook substantial retrofit or modification of equipment.

4. ACTUAL VS. EXPECTED CONSUMPTION

To determine what "normal" consumption would have been in the absence of the curtailment ordinance and associated factors, we ran regressions on a monthly time series of data in the pre-crisis period, using the explanatory variables of (1) the price of electricity, (2) economic activity, (3) temperature, and (4) minutes of daylight. Because we are analyzing a short-run adjustment, those variables that related to basic structural changes over time could be excluded. Major changes were not expected in variables that influence long-run behavior, such as stock of appliances and their energy using characteristics, demographic and distributional factors, structure of unemployment, and so forth. In the short run, there is also relatively less variation in the values of some of the explanatory variables which affect structural changes in electricity consumption, and this results in more reliable short-run predictions.

Regressions in Table 1 were estimated for aggregate production and consumption of electricity in DWP, peak kw, and on a disaggregate level for the major consumer groups in this area--namely the commercial, industrial, and residential sectors--giving six equations in all. Monthly data covering the period from December 1970 up to and including August 1973 were used for estimation.[9]

The dependent and independent variables are discussed in more detail in Acton and Mowill [2, pp. 6-16]. The effect of fluctuations in economic activity and income is best captures by the employment variable.[10] This study examines only the effects of employment on electricity use and not the effect of electricity consumption (or the curtailment ordinance) on employment and other measures of economic activity. A previous study found no evidence of significant adverse consequences of the curtailment on total civilian employment or employment in the manufacturing sector.[11]

Selection of a price variable presents a problem in electricity demand studies. The Department of Water and Power, like most utilities in the United States, supplies electricity on a declining block rate schedule (with different rates for residential customers and industrial and commercial customers). Economic theory holds that marginal price is the appropriate variable for decisionmaking, but in this time period, the average price and marginal price for both rate schedules are highly correlated ($R^2 = 0.95\text{-}0.99$). We estimated our equations with both average and marginal price and found the pattern of significance the same and remaining coefficients in the equations quite stable.

Weather and minutes of daylight also have a potentially important effect on energy consumption. Cooling degree days for the month (Cool) is expected to be important due to the significant air conditioning load. Heating degree days (Heat) is potentially important, although electricity is not the major source of heating in the area.[12] Minutes of daylight (Light) is entered to test the hypothesis that additional external light could reduce energy use by reducing internal lighting loads.

Table 1

REGRESSION RESULTS[a]

Eq.	Dependent Variable	Explanatory Variables: Constant	Price[b]	Employment	Heat	Cool	Light	d.o.f.[c]	F	Corrected R^2	Durbin Watson Statistic
1	NEL	-0.00 (3.3)	113.6 (.165)	1104.0 (4.6)	557.6 (4.5)	825.9 (11.3)	2.16 (0.54)	27	44.8	0.87	2.79
2	Peak kw	-5844.0 (4.0)	-2.0 (1.1)	3.3 (5.3)	0.48 (1.5)	2.2 (11.4)	-0.014 (1.4)	27	50.6	0.89	2.02
3	Total sales	-1385.0 (1.8)	-0.17 (0.18)	1.02 (3.08)	0.202 (1.36)	0.469 (4.86)	-0.006 (1.3)	27	11.2	0.62	2.04
4	Commercial sales	-699.7 (1.8)	0.3 (0.66)	0.478 (2.9)	-0.02 (0.33)	0.185 (3.9)	-0.0007 (0.33)	27	17.9	0.72	2.61
5	Industrial sales	-104.3 (0.6)	0.03 (0.1)	0.116 (1.48)	0.05 (1.5)	0.06 (2.97)	0.001 (1.2)	27	5.2	0.40	1.53
6	Residential sales	-1258.0 (2.15)	-2.66 (2.3)	0.75 (3.04)	-0.03 (0.3)	0.17 (2.66)	-0.008 (2.7)	27	3.7	0.30	1.98

[a] t-values in parentheses. All equations are in linear form.

[b] Price deflated by the consumer price index. (1967 = 1.0) in 1/10 mill per kwh.

[c] Degrees of freedom.

EMPIRICAL RESULTS

The general form of all equations is a linear specification with the amount of electricity as the dependent variable. Net energy for load and monthly peak kw are recorded in the month of production, so current values of the explanatory variables are used. Since sales are recorded by month of billing, the explanatory variables in these equations are lagged one month (except for residential equations, where they are lagged two months, since billing is bimonthly).[13]

In general, the results of the regression analysis were quite satisfying for the purpose of this analysis. Table 1 presents the results of the regression analysis for the two production equations and the four sales equations. The equations contain few surprises for those who are familiar with the operation of a power system--but it is useful to have quantitative estimates of the effects of important factors. The single equation, ordinary least squares estimates of the models, provided very good fits to the Net Energy for Load (NEL), peak kw, total sales, and commercial sales data. The industrial and residential sales equations have lower values of $\bar{R}^2$, but the residential equation has statistically significant coefficients on all but one of the important variables. The lower correlation coefficient ($\bar{R}^2$), combined with statistically significant coefficients, means that those variables are important, but that there is still a substantial amount of variance in electricity sales to be explained.[14] The industrial equation is generally not satisfactory. Since the number of customers classified as industrial changed after the estimation period, this poorer fit is of less consequence since we would probably not wish to use it for prediction purposes.

With the exception of the residential sales equation, the price variable was not statistically significant. The measurement of a significant price effect depends on both behavioral and empirical factors. At the behavioral level, customer response to a change in the price of electricity depends in part on the relative share of income (or total expenses) going to electricity, and on the availability of substitutes for electricity in the short run, given the present stock of appliances and/or the present production processes. Empirically, the detection of a price effect on the level of consumption depends on the amount of variation in the price variable during the estimation period.

The combination of these factors is such that we do not find a statistically significant price effect in any but the residential sales equation in the pre-ordinance period for which our equations were estimated. This indicates that in this period, industrial and commercial customers either behaved as if the cost of electricity constituted a relatively small part of their total expenses and that consumption was not significantly affected by the actual price changes, or that satisfactory substitutes were not available in the short run. The result is that the magnitude of the actual price changes (excluding the effect of potential surcharge) apparently did not influence the level of electricity consumption.

Since electricity prices have increased relatively more in the post-estimation period, it is possible that different coefficients apply; thus our inconclusive results about the effect of price should not be extrapolated. In particular, non-statistical evidence suggests that commercial customers may be more aware of energy prices in the post-ordinance period than before. When we interviewed individual customers, several respondents volunteered that because of the higher levels of electricity prices, they were maintaining energy conservation measures even after the ordinance had been suspended.[15]

Economic activity--as measured by employment--was highly significant in all equations but industrial sales (which is generally unsatisfactory). Higher levels of economic activity are historically associated with greater consumption of electricity.

Temperature plays a significant role in electricity consumption. Cooling degree days (that is, hot weather that increases the demand for air conditioning or refrigeration) have a very significant effect on NEL, the peak kw, and on all breakdowns of electricity sales. Heating degree days have a generally insignificant effect in this sample--probably due to the relatively uncommon use of electricity for heating in Los Angeles.

Minutes of daylight have an insignificant effect on electricity consumption in all but the residential sales equation. This implies that, by and large, the use of electricity by commercial and industrial users takes place regardless of the amount of outside light. It may further imply that year-round daylight saving time is expected to have a very small effect (if any at all) in reducing use of electricity.[16]

COMPARISON USING PREDICTION MODEL

The year-by-year comparison in Section 3 shows a substantial response during and after the period the ordinance was in effect. It does not, however, indicate whether other factors such as weather made it easier or harder to achieve these effects. The results of the estimated equations were used to "predict" (or estimate) what the total and sectoral electricity consumption would have been from September 1973 through the summer of 1974 given the observed values of the explanatory variables.[17] The deviation in actual consumption from "predicted" is then a measure of the true curtailment effect. Figure 3 shows the same basic pattern of reduction in electricity consumption that was revealed in the year-by-year comparison.[18] Energy production (NEL) and commercial sales fell by even more than implied by the year-by-year comparison. Commercial sales remained approximately 30 percent below predicted into the summer of 1974.

Residential sales fluctuated between 3 and 14 percent below that predicted by the statistical model during the period the ordinance was in effect. By summer 1974, actual residential sales were above those predicted by the model.

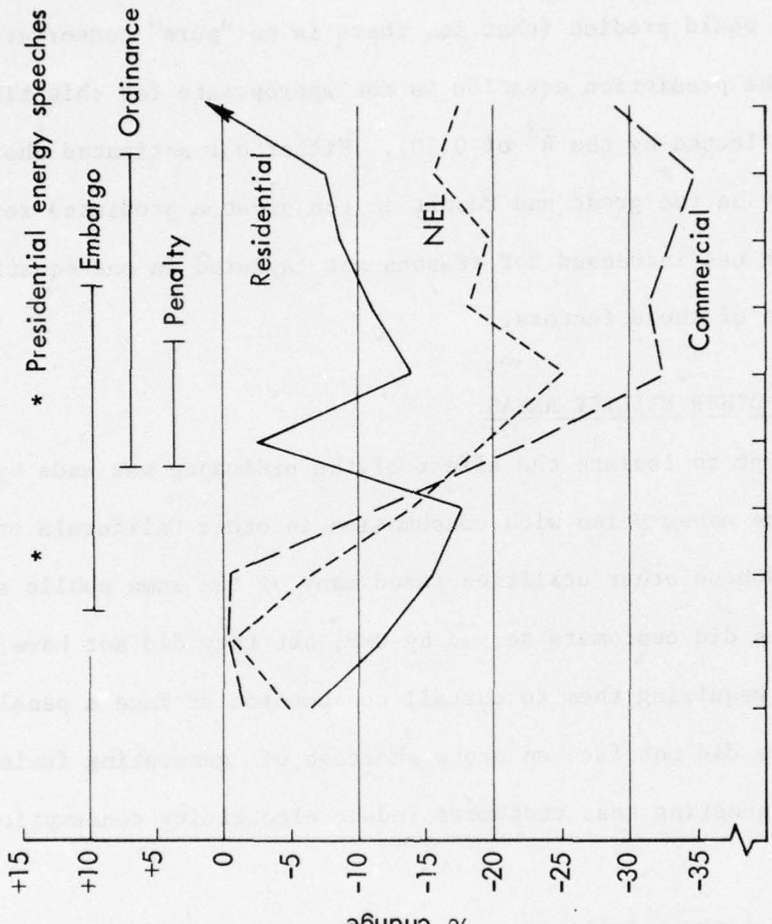

Fig. 3 — Percentage change in monthly electricity consumption 1973–74 versus predicted consumption

This does not mean, however, that residential users were consuming more electricity than they did before the energy shortage. Figure 2 shows residential sales in the summer of 1974 about 13 percentage points below summer 1973. This apparent inconsistency has two interpretations. First, given the effects of weather and other variables, the residential customers are not consuming much below what one would predict (that is, there is no "pure" conservation effect). Second, the prediction equation is not appropriate for this time period (which is reflected by the $\bar{R}^2$ of 0.30). Either our estimated short-run price elasticity may be too great and result in too great a predicted reduction in demand, or demand has increased for reasons not captured in our equation--or for a combination of these factors.

5. COMPARISON WITH OTHER UTILITY AREAS

The third attempt to isolate the effect of the ordinance was made by comparing Los Angeles consumption with consumption in other California utilities. Customers of these other utilities faced many of the same public appeals and media exposure as did customers served by DWP, but they did not have a mandatory ordinance requiring them to curtail consumption or face a penalty. Since these utilities did not face an acute shortage of generating fuels, a voluntary program requesting that customers reduce electricity consumption was in effect.

The three other largest utilities are all privately owned and regulated by the California Public Utilities Commission (CPUC). Together with the Los Angeles Department of Water and Power, they account for most of the electricity sold in California. Two of the three private utilities each serve much larger geographic areas than does DWP, and their service areas are more heterogeneous than the largely urban/suburban nature of the DWP area. Table 2 shows the relative shares of kwh sales to residential, commercial, and industrial customers (as defined by each utility) in all four utilities in June 1974.[19]

Table 2

RELATIVE SHARES OF kwh TO RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL CUSTOMERS, JUNE 1974, CALIFORNIA UTILITIES

Utility	Customer		
	Residential (%)	Industrial (%)	Commercial (%)
Los Angeles Department of Water and Power (DWP)	26	27	47
Southern California Edison (SCE)	30	41	29
Pacific Gas and Electric (PG&E)	34	30	36
San Diego Gas and Electric (SDG&E)	37	26	37

The percentage change in total electricity sales compared to the preceding year for the four utilities is shown in Figure 4.[20] We should not regard the observed differences between the utilities as a rigorous measure of the effect of the ordinance for the following reasons. First, we are not controlling for the effects of weather, price, employment, or daylight in this comparison. Since Section 4 showed that these variables were significant in explaining DWP's historical consumption patterns, we could expect to improve our year-by-year comparison by performing a similar analysis in other utilities. Second, as mentioned above, the other utilities generally serve a more heterogeneous area (with a different mix of customers) so that changes in total sales may be misleading. Third, we have not controlled for the details of the scope and time period of the reduction activities that were implemented in response to the CPUC order. Finally, the data in Figure 4 are not adjusted for changes in number of customers, although this does not affect the overall picture substantially.[21]

As Figure 4 shows, all utilities started the period of energy shortage at or above the sales level of 1972. Total sales fell initially in all utilities, but the sales to DWP customers fell substantially more and were 15 to 20 percentage points below the reductions observed in other utility areas during the period of the ordinance.

An analysis of reduction in use by customer class in each of the four utilities confirms the specific nature of the ordinance impact. The commercial customers in DWP were required to reduce their consumption by the greatest amount, and they did so. Commercial customers in SCE's service area also reduced their consumption a few percentage points more than any other class of customer. The picture is mixed in the other two utilities, with commercial customers not responding noticeably differently than other customers. The lack of a spread in reduction by class of customer in the other two utility

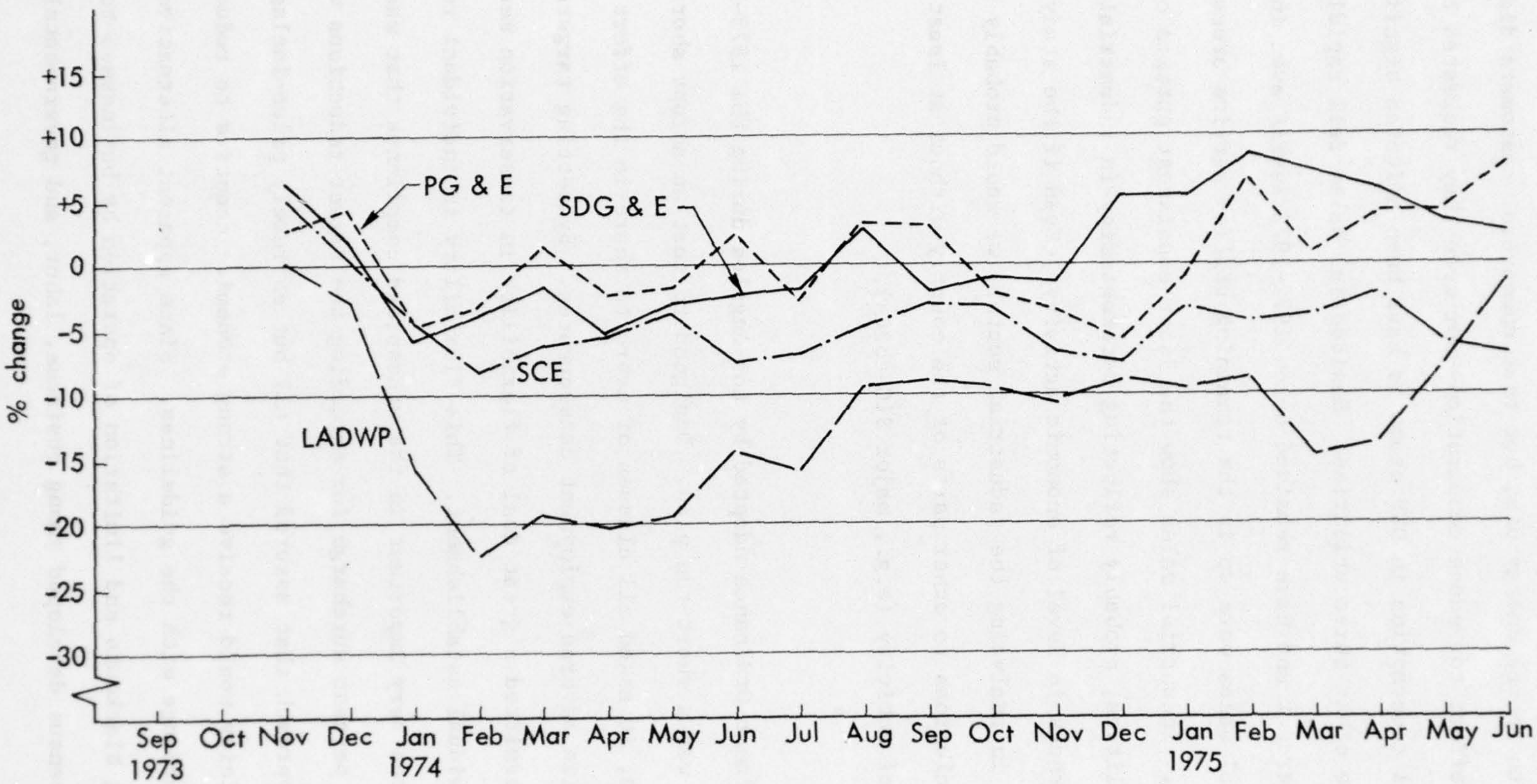

Fig. 4 — Percentage change in monthly electricity sales versus 1972-73.
Four California utilities

service areas suggests that all customers in those areas were responding to an overall appeal to reduce energy use, but that commercial customers did not make a special effort to reduce consumption--nor were they requested to do so.

Residential consumption in DWP seems to have been affected significantly more than in the other three utilities. Residential sales fell rapidly in DWP to almost -20 percent and have remained below 1972-1973 levels even in 1975, while residential sales were up in the remaining utility service areas before the end of 1974. Industrial sales show the least consistent pattern of change in all four utilities, probably reflecting heterogeneity in industrial mix and regional differences in level of economic activity. Even if the study had been more successful in analyzing the industrial sector, we would probably not wish to transfer conclusions to other parts of the country without at least disaggregation by type of activity (e.g., major SIC codes).

6. CONCLUSIONS

The Curtailment Ordinance adopted by Los Angeles during the 1973-1974 energy "crisis" was a short-run plan. Designed to meet an abrupt shortage of generating fuels, it asked all classes of users to share in the effort while trying to minimize adverse employment consequences. By setting targets for reduction, it permitted a great deal of flexibility in conservation measures adopted by individual establishment. This flexibility in individual response seems to have been very important in the widespread compliance that was observed. The use of a 50 percent surcharge for exceeding the target reductions was a "semi-market" approach that assured that all but extremely price-inelastic users of electricity would receive a strong economic incentive to reduce consumption in accordance with the guidelines. Since apparent alternative policies included rolling blackouts and limitation of operation by businesses to 50 hours per week, a consensus developed among business, labor, and governmental leaders that a percentage curtailment was a relatively more attractive means of meeting the shortage.

In facing a fuel shortage or similar crisis, policymakers generally have two, possibly competing, objectives: (1) to endure in the short-run with minimum disruptions, and (2) to promote rational adjustments in all forms of consumption in the long run--probably through relatively greater reliance on the pricing mechnism because of its generally superior allocative results. It appears that Los Angeles achieved both objectives with the curtailment ordinance. In the short run, a significant reduction took place in electricity consumption, no matter how measured. In the long run, it appears that a permanent change has taken place in the level of consumption.

It is clear that the ordinance worked as a short-run policy in successfully reducing demand during the period of fuel shortage and in avoiding system outages. No matter which analytic approach we take in measuring the impact of the ordinance and surrounding effects, the conclusion is that the response was rapid and substantial. Table 3 compares the target levels of reduction with measured impact by the three approaches used in the text. Except for industrial sales, average reductions during the five months the ordinance was in effect were in excess of that required by the ordinance (column 2 versus column 1). This pattern is repeated when we measure the difference between actual level of electricity use and the expected level (using regression predictions, column 3), as well as when we compare consumption in other utility service areas (column 4).

The policies seem to have had a lasting effect on the pattern of consumption--not only causing a one-time reduction in the consumption of energy but also moving to a slower rate of growth. In the 16 months following suspension of the ordinance, total sales were 9 to 16 percent below the corresponding month in 1973. In contrast, total sales in the other three utilities were off

Table 3

SUMMARY OF CURTAILMENT TARGETS AND OBSERVED
REDUCTION IN ELECTRICAL SALES BY SECTOR, JANUARY-MAY 1974

Sector	Target Reduction (Phase I of Ordinance) (%)	Average Actual Reduction Over Preceding Year (%)	Average Reduction in Excess of Predicted Use (%)	Reduction in Excess of Observed Changes in Other Major California Utilities (%)
Residential	10[a]	17	9	11
Commercial	20	27	31	18
Industrial	10	4	8[b]	-1
Total	≈ 12	19	22	15

[a] Nominal reduction of 10 percent required - but applied to only 2/3 of the users.

[b] Four months used due to changing number of customers classified as industrial.

between 3 and 8 percent in January and February 1974 and by the end of the summer, they were higher than the preceding year in two utilities and off by 2 to 5 percent in the third utility. During the first 6 months of 1975, total sales in two out of three utilities were above 1973 levels. These longer-run effects may be due to the general appeal to conserve as well as greater price awareness as the ordinance called attention to the financial savings that result from a reduction in consumption. The financial advantage of reduced consumption has been reinforced by higher rates and a number of the commercial establishments interviewed told us that this was the major reason for their continued conservation.[22]

It is unlikely that a price change of the usual type (i.e., raising the rates schedule) alone would have achieved a significant reduction, in the short run, of the magnitude achieved by the curtailment ordinance. With the exception of the residential sector, there was no evidence in this service area of substantial short run elasticity of demand with respect to price. Even if the estimated elasticities reported from national cross-sectional data are used, they generally imply that price would have to increase more than 100 percent to achieve the 17 percent reduction in demand observed immediately after the enactment of the ordinance.[22] Such large price increases obviously encounter significant customer resistance and are therefore difficult politically to impose if a less painful policy alternative seems to exist.

In assessing the transferability of the Los Angeles plan to other utilities and to other parts of the country, several factors should be noted. First, the ordinance was the result of the recommendations of a broadly based committee of business, civic, and labor leaders. This broad representation of the customer groups probably helped assure realistic targets for reductions and contributed substantially to widespread compliance with the provisions. Under the largely voluntary plan ordered by the public utilities commission for private utilities in the state, most classes of customers wanted to receive special treatment. Second, although the Los Angeles plan was implemented by a city ordinance, it is not uniquely a policy alternative for municipal utilities. The basic provision--relying on a rate surcharge based on historical consumption--could be ordered by the public utilities commissions of most states. Third, the large overall reduction in DWP consumption is due in part to the fact that about 50 percent of the sales go to commercial customers (versus 38 percent nationally), and these customers seemed to have greater scope for reduction in use. Fourth, the ordinance did create a significant administrative burden. Some customers found it difficult to adapt to the requirements, and 10 percent of the residential customers covered by the ordinance appealed for adjustment in their percentage. In contrast, less than 2 percent of the commercial and industrial customers appealed. Had the penalties of the ordinance actually been levied, it is possible the number of appeals would have risen to a level that would have completely overburdened the system.

NOTES

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1. See, for example, "FEA Plots Ways to Cut Utility Gas Use as Means to Ease Winter Shortage," Electrical Week, Sept. 1, 1975, p. 1; and "FEA Shaping Embargo Contingency Plan that Would Tax Power Users," Ibid., Sept. 8, 1975, p. 1.
2. PL 94-163; Gene Delatori, personal communication, March 19, 1976.
3. The details of the plan, as well as a description of the events preceding its enactment, are contained in Acton, Graubard, and Weinschrott[1]. That report also describes the results of an analysis of the conservation measures adopted by individual commercial establishments. See also Williams [4], the report of the Mayor's Energy Coordinator, summarizing some aspects of the impact of the ordinance and recommending modifications.
4. The lowest third (by kwh) of residential customers were exempted from the requirement.
5. Since we are talking about values of r between 0.10 and 0.20, this implies elasticities with respect to the marginal price less than 0.05 and 0.10, respectively, and virtually no elasticity with respect to the 50 percent surcharge on consumption up to $(1-r)$ Q. If the customer were perfectly informed and able to control his monthly consumption pre-

cisely, then most customers would consume exactly (1-r) Q. In general, we would expect people to try to limit consumption to a level somewhat below (1-r) Q in order to be sure of not paying the 50 percent surcharge. As originally enacted, the ordinance had no provision for averaging between two billing periods if consumption in one period were out of line. Later amendments to the ordinance permitted such averaging.

6. The DWP classification of customer is used. For purposes of the ordinance, commercial and industrial customers were distinguished by SIC (Standard Industrial Classification) codes. Larger master-metered apartments are included in the commercial sector sales, although they were required to curtail use by only 10 percent.

7. The apparent rise in kwh sales to industrial customers during and after the ordinance is attributable in large part to a significant increase in the number of customers classified as "industrial." Since the number of industrial customers is small (10,000 to 15,000), an increase of a few thousand industrial customers is large in percentage terms. In the past, some customers whose business was truly industrial (as defined by the Standard Industrial Classification Code) may have been classified as commercial -- chiefly because they were small. Since the rate structure for industrial and commercial customers was the same, this caused no problem. Once the curtailment plan was enacted, however, it was advantageous for customers who qualified as industrial to change their classification from commercial, because the curtailment ordinance required only 10 percent reductions in industrial consumption. Consequently, the number of customers classified as "industrial" increased by a few thousand during the first half of 1974 -- causing a 20 percent increase. This increase is balanced by a reduction in the number of customers classified "commercial," but due to the larger number of customers (about 120,000) this was less than 2 percent. The increase in number of residential customers was less than 1 percent

during this time period. Industrial sales per customer were off during the entire period the ordinance was in effect.

8. Acton et al., [1].

9. This period was selected because it captures recent patterns of consumption without covering the time period when a possible energy shortage started to appear.

10. We would like to have included a measure of value added or gross product for Los Angeles as an explanatory variable in the commercial and industrial equations, but none is available on a monthly basis. We experimented with measures of downtown department store sales, but since they were not seasonally adjusted they provided little or no explanation. Department store sales have a very high "spike" for the month of December and low fluctuating values for other months. Using manufacturing employment in place of total employment left the other coefficients unchanged in our analysis. Similarly, disposable personal income would be desirable for the residential equation, but it is available only on an annual basis for Los Angeles and therefore cannot be used in a monthly model.

11. Acton, et al., [1].

12. One cooling degree-day is given for each degree that the daily mean temperature is above that of 65°F. One heating degree-day is given for each degree that the daily mean temperature is below the base of 65°F.

13. A simple linear specification was used -- because the linear results were sufficiently satisfying for these purposes, and alternative specifications impose unacceptable restrictions. The equations were estimated by ordinary least squares (OLS). The use of monthly time series did not justify the inclusion of a lagged dependent variable, since our aim was to explain short-run fluctuations. There was no indication that a multi-collinearity problem was involved, since all experiments with alternative specifications left the corrected coefficient of determination ($\bar{R}^2$) stable, supported by the values of the t- and F-statistics. Furthermore, the values of the

Durbin-Watson test statistic indicate no positive autocorrelated disturbance terms.

14. The residential sector is billed bimonthly, and arbitrary adjustments are made by DWP in the recording of monthly sales to this category of customers. The result is a "flattening" of the yearly load curve, and some of the actual fluctuation in the data is removed. Furthermore, in each observation, two periods of electricity consumption are regressed against one period's values of the explanatory variables. Not surprisingly, these regressions provided less satisfactory explanations.

15. Acton, et al., [1].

16. We also estimated all equations with a dummy variable for daylight saving time over the time period December 1970 through August 1973. The coefficient was consistently not significantly different from zero.

17. This concept of prediction should not be confused with a forecast which was based on estimates of future values of the explanatory variables.

18. We did not plot the industrial sector comparison because the estimated model is not very satisfactory in terms of the precision of the coefficients or the overall fit to the data and because of the change in number of customers classified as industrial.

19. Agricultural and other sectors excluded from total so that percentages add to 100. The exclusion of agriculture is not significant except in PG&E, where sales to agriculture are about 12 percent of retail sales (when agriculture is included, the sales to other sectors are: residential, 30 percent; industrial, 27 percent; and commercial, 31 percent).

20. The DWP data are obtained directly from the Chief Administrator's office. The data for the three private utilities are taken from reports entitled Effectiveness of Electric Conservation Programs, submitted to The California Public Utilities Commission in response to Decision 82139.

21. With one exception, the number of customers increased in all four California utilities, so that the year-by-year plot of percentage change in kwh per customer lies a few percentage points below the plots in Figure 4. The increase in number of residential customers in summer 1974 was about 3 percent for PG&E, 2 percent for SCE, 5 percent for SDG&E, and 1 percent for DWP over summer 1973. Commercial customers increased by approximately 2 percent, 1 percent, 4 percent, and -1.5 percent, respectively. SCE reports that the number of industrial customers declined 2.3 percent from July 1973 to July 1974. Although the adjustment for number of customers shifts all curves slightly, it does not change any of the conclusions about the relative impact of the ordinance and associated influences.

22. Acton, et al., [1].

23. See, for instance, Taylor [3] for a recent review of demand studies. With the exception of one study, the estimates of short-run elasticities lie between -0.13 and -0.22 for U.S. data.

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